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UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA

ASHLEY M. GJOVIK, *an individual*,

Plaintiff,

vs.

APPLE INC., a corporation,

Defendant.

Case No. 3:23-CV-04597-EMC

PLAINTIFF'S EXHIBIT

Chapter 27: Semiconductor Fabrication Facilities

General Comments

The invention, development and exploitation of semiconductor technology has changed the world. Without integrated circuits, and the microchips (or “chips”) they are composed of, the world of high technology would not exist. With the benefits of living in a high-tech age come some unique and pressing challenges. The manufacture of microchips is a complex, hazardous and demanding operation involving state-of-the-art design and manufacturing techniques, specially designed processing centers and a highly trained workforce. Despite these rigors, the dangers of the processes can neither be avoided nor ignored.

The manufacture of semiconductors and microprocessors has developed into its own industry within the last 30 years. The proliferation of computer technology has resulted in the incredible expansion of the semiconductor manufacturing industry. These sophisticated products require a special processing environment and rules to match the technology unique from other hazardous materials processes. Considering the unique and often acute hazards of many materials used in semiconductor processing, this industry has maintained a solid safety record.

Purpose

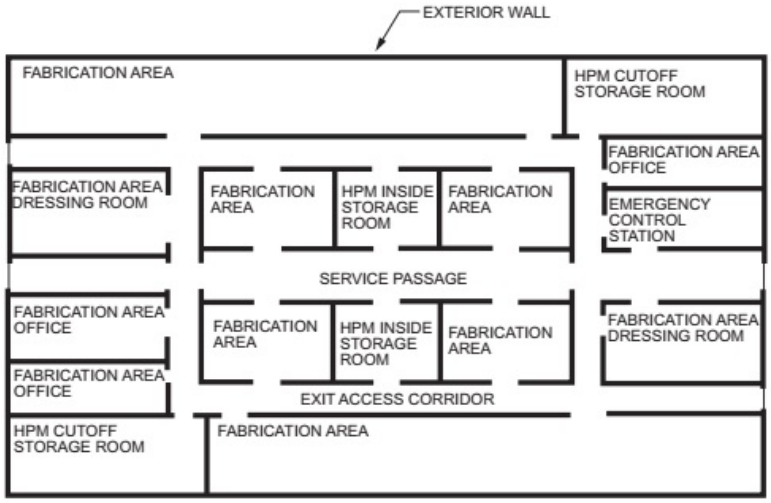
The requirements of this chapter are intended to control hazards associated with the manufacture of semiconductors. Though the finished product possesses no unusual hazards, materials commonly associated with semiconductor manufacturing are often quite hazardous and include flammable liquids; pyrophoric and flammable gases; toxic substances and corrosives. The requirements are concerned with both life safety and property protection. However, the *fire code official* should recognize that the risk of extraordinary property damage is far more common than the risk of personal injury from fire.

SECTION 2701
GENERAL

2701.1 Scope.

Semiconductor fabrication facilities and comparable research and development areas classified as Group H-5 shall comply with this chapter and the *International Building Code*. The use, storage and handling of hazardous materials in Group H-5 shall comply with this chapter, other applicable provisions of this code and the *International Building Code*.

❖ Semiconductor facilities are unique facilities that, due to their size, complex layout and the logistics of their operations, have been provided with a unique package of requirements. In some cases, these unique requirements will allow the maximum allowable quantities (MAQs) established in Tables 5003.1.1(1) and 5003.1.1(2) to be exceeded. The hazardous material MAQs are essentially replaced by more specific allowances and restrictions in this chapter. In cases where a material hazard is not addressed in this chapter, the applicable requirements found in Chapter 50 and associated material-specific chapters of the code and the *International Building Code*® (IBC®) would still apply regardless of whether the MAQs have been exceeded. Semiconductor fabrication facilities are classified in Occupancy Group H-5 and are to comply with the applicable provisions of IBC Section 415.11. Commentary Figure 2701.1(1) shows a typical layout of such facilities. Commentary Figure 2701.1(2) shows typical hazardous production materials (HPM) found in semiconductor manufacturing.



Commentary Figure 2701.1(1)
TYPICAL COMPONENTS OF AN HPM FACILITY

MATERIAL	DESCRIPTION OR USE	NFPA 704 HAZARD CLASSIFICATION			
		Health	Flammability	Reactivity	Other
Acetic acid	Corrosive liquid used for wet etching (metal)	2	2	1	
Acetone	Flammable liquid used for wafer cleaning	1	3	0	
Ammonium fluoride	Corrosive for wet etching (oxide)	3	0	0	
Arsenic trichloride	Diffusion	3	0	1	~~W~~
Arsenic trioxide	Diffusion	4	0	0	
Arsine	Poison flammable gas used for epitaxial growth, diffusion and ion implanation	4	4	3	
Boron tribromide	Corrosive liquid used for diffusion	4	0	3	~~W~~
Boron trichloride	Nonflammable corrosive gas used for diffusion	4	0	1	~~W~~
Chlorine	Poison gas used for dry etching	3	0	0	OXY
Diborane	Highly reactive flammable gas used for diffusion	3	4	3	~~W~~
Dichlorosilane	Flammable liquefied gas used for epitaxial growth	4	4	4	
Gallium	Reactive metal used as a semiconductor crystal material	1	0	3	
Gallium arsenide	Reactive metal salt used as a semiconductor crystal material	3	0	0	

MATERIAL	DESCRIPTION OR USE	NFPA 704 HAZARD CLASSIFICATION			
		Health	Flammability	Reactivity	Other
Gallium arsenide phosphide	Reactive metal salt used as a semiconductor crystal material	3	0	0	
Germanium	Reactive metal used as a semiconductor crystal material	0	0	3	
Hydrofluoric acid	Highly corrosive liquid or gas used for wet etching (oxide)	4	0	0	
Hydrogen peroxide[a]	Organic peroxide used for wafer cleaning	2	0	1	OXY
Isopropanol	Flammable liquid used for wafer cleaning	1	3	0	
Methanol	Flammable liquid used for wafer cleaning	1	3	0	
Nitric acid	Corrosive liquid used for wet etching (metal)	3	0	0	OXY
Oxygen (liquid)	Oxidizing gas used for oxidation	3	0	0	OXY
Phosphine	Flammable liquefied poison gas used for diffusion and ion implantation	4	4	4	
Phosphoric acid	Corrosive liquid used for wet etching (metal)	2	0	0	
Phosphorus oxychloride	Corrosive liquid used for diffusion	4	0	3	₩
Phosphorus pentoxide	Corrosive solid sublimed for use in diffusion	4	0	3	₩
Phosphorus tribromide	Corrosive liquid used for diffusion	4	0	3	₩
Silane	Pyrophoric gas used for oxidation	2	4	4	
Silicon	Flammable solid (metal) used as a semiconductor crystal material	2	4	2	₩
1, 1, 1-Trichloroethane	Mildly flammable solvent (difficult to ignite) used or wafer cleaning	2	1	0	
Tetrachlorosilane	Flammable liquid used for epitaxial growth	3	4	2	₩

a. NFPA 704 values for 35 to 52 percent by weight (the most concentration) are listed. The reactivity hazard increases to 3 at concentrations above 52 percent.

Commentary Figure 2701.1(2)
HAZARDOUS PRODUCTION MATERIALS (HPM) USED IN THE MANUFACTURE OF SEMICONDUCTORS

2701.2 Application.

The requirements set forth in this chapter are requirements specific only to Group H-5 and shall be applied as exceptions or additions to applicable requirements set forth elsewhere in this code.

❖ Chapter 27 requirements are specific only to Group H-5 occupancies, with the requirements applied as exceptions or additions to requirements addressed elsewhere in the code. Where Chapter 27 contains a specific requirement for a certain condition and a general requirement for the same condition exists elsewhere in the code, the specific Chapter 27 requirements are to be applied. For example, general requirements for spill control and containment for use conditions involving hazardous materials in amounts exceeding MAQs are found in Section 5004.2, with conditions specific to Group H-5 occupancies addressed in Section 2705.2.3.3. For Group H-5 occupancy conditions, the specific Section 2705.2.3.3 requirements take precedence over the general requirements addressed in Section 5004.2.

2701.3 Multiple hazards.

Where a material poses multiple hazards, all hazards shall be addressed in accordance with Section 5001.1.

❖ All hazard classifications of a material are to be considered. For example, glacial acetic acid is classified as both a Class II combustible liquid and a corrosive liquid. Thus, for glacial acetic acid, the requirements for both Class II combustible liquids and corrosive liquids must be met. This section restates the conditions found in Section 5001.1.

2701.4 Existing buildings and existing *fabrication areas*.

Existing buildings and existing *fabrication areas* shall comply with this chapter, except that transportation and handling of HPM in *corridors* and enclosures for *stairways* and *ramps* shall be allowed where in compliance with Section 2705.3.2 and the *International Building Code*.

❖ Although the adoption and enforcement of code requirements specifically addressing semiconductor manufacturing and similar research and development operations have been in place for over 20 years, there are still some facilities that predate the adoption of regulations specific to these operations. This section requires modifications to existing facilities to comply with certain provisions of IBC Section 415.11. Additionally, requirements found in Section 2705.3.2 of this code and Section 415.11.2 of the IBC must be met where existing conditions or modifications do not include service *corridors*

and existing exit access *corridors* that are used to transport HPM to *fabrication areas*.

2701.5 Permits.

Permits shall be required as set forth in Section 105.5.

❖ The process of issuing permits gives the *fire code official* an opportunity to carefully evaluate and regulate hazardous operations. Permit applicants should be required to demonstrate that their operations comply with the intent of the code before the permit is issued. The process also notifies the fire department of the need for prefire planning for the hazardous property. See the commentary to Section 105.5 for a general discussion of operations requiring an operational permit, notably Section 105.5.22 for a discussion of specific quantity-based hazardous materials operational permits and Section 105.5.23 for HPM operational permits.

Chapter 7: Factory/Industrial Zones

General Comments

When designing factory or industrial sites, it is important to look at the impact on the surrounding districts/uses. The intent is to encourage the use of the land and buildings needed for major industrial purposes that are compatible with the nearby existing and planned uses. Factory and industrial districts may be placed in outlying areas so that the public health, safety and welfare is protected for those residents by preserving the social character and economic viability of surrounding properties.

Purpose

A factory or industrial zone is for uses that serve a major market. It is for those businesses engaged in manufacturing, processing or dismantling. These areas are designed to be away from residential and smaller commercial areas because of the high volume of traffic or the use of chemicals in processing.

701.1 FI zones.

Allowable factory/*industrial* (FI) zone uses shall be:

Division 1. Any light-manufacturing or *industrial* use, such as warehouses, research or testing laboratories, product distribution centers, woodworking shops, auto body shops, furniture assembly, dry cleaning plants, places of religious worship, public and governmental services, machine shops, and boat building storage yards.

❖ The F1, Division 1 zone will utilize space for warehouses, distribution centers and automotive body/paint shops. It is interesting to note that government services and places of worship are also allowed in this zone. An industrial park that fosters industrial research, along with storage yards, is also permitted. FI zones are designed to accommodate all forms of industry but are not to include hazardous material storage.

Division 2. Any use permitted in the FI, Division 1 zone and stadiums and arenas, indoor swap meets, breweries, liquid fertilizer manufacturing, carpet manufacturing, monument works, and a regional recycling center.

❖ The FI 2 zone will accommodate the need for large parking areas associated with stadiums or arenas, regional uses such as recycling centers that service a large area such as a county and uses that may bring a higher noise level such as manufacturing plants or stadiums during events. Any use described in FI 1 is allowed to be in this zone.

Division 3. Any use permitted in the FI, Division 2 zone and auto-dismantling yards, alcohol manufacturing, cotton gins, paper manufacturing, quarries, salt works, petroleum refining, and other similar uses.

❖ This zone tends to be the furthest from any residential zones because of the use of chemicals in manufacturing or refining. The noise levels may also be higher as auto dismantling yards are allowed or heavy truck traffic from quarries or other similar industrial refineries/factories. Any use described in an FI 2 zone is also allowed in an Fl 3 zone.

TABLE 16-5
NFPA 704 Hazard Ratings by Hazard Categories

NFPA 704 HAZARD RATING	HAZARD CATEGORIES		
	Health	**Flammability**	**Instability**
4	Materials that under emergency conditions can be lethal.	Materials that rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or that are readily dispersed in air and burn readily.	Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures.
3	Materials that under emergency conditions can cause serious or permanent injury.	Liquids and solids (including finely divided suspended solids) that can be ignited under almost all ambient temperature conditions.	Materials that in themselves are capable of detonation or explosive decomposition or explosive reaction but that require a strong initiating source or must be heated under confinement before initiation.
2	Materials that under emergency conditions can cause temporary incapacitation or residual injury.	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.	Materials that readily undergo violent chemical change at elevated temperatures and pressures.
1	Materials that under emergency conditions can cause significant irritation.	Materials that must be preheated before ignition can occur.	Materials that in themselves are normally sTABLE but that can become unsTABLE at elevated temperatures and pressures.
0	Materials that under emergency conditions would present no hazard beyond that of ordinary combustible materials.	Materials that will not burn under typical fire conditions, including intrinsically noncombustible materials such as concrete, stone and sand.	Materials that in themselves are normally stable, even under fire conditions.
NFPA 704 Special Hazards			
A NFPA 704 special hazard designations represent hazardous materials that may be water reactive, an oxidizer, corrosive or a simple asphyxiation hazard. A water-reactive hazard is designated with a stricken-through W ($$). Oxidizers can be represented with the letters “OX.” Simple asphyxiants such as inert gases or inert cryogenic fluids are designated as “SA.”			
[Ref. NFPA 704]			

TABLE 16-2
IFC Classification Criterion for Highly Toxic and Toxic Materials

IFC CLASSIFICATION	EXPOSURE ROUTE		
	Inhalation Toxicity Threshold	**Absorption Toxicity Threshold**	**Ingestion Toxicity Threshold**
Highly Toxic	200 ppm or less; 2 mg/L or less	200 mg/kg or less	50 mg/kg or less
Toxic	Greater than 200 ppm but not more than 2,000 ppm; greater than 2 mg/L but not more than 20 mg/L	Greater than 200 mg/kg but not more than 1,000 mg/kg	Greater than 50 mg/kg but not more than 500 mg/kg
[Ref. 202**]**			

mg/kg = milligram/kilogram of body weight

mg/L = milligram/liter of mist, fume or dust

ppm = parts per million of gas or vapor

E102.2 Health hazards.

Materials classified in this section pose a health hazard.

E102.2.1 Highly toxic materials.

Examples include:

1. Gases: arsine, cyanogen, diborane, fluorine, germane, hydrogen cyanide, nitric oxide, nitrogen dioxide, ozone, phosphine, hydrogen selenide, stibine.
2. Liquids: acrolein, acrylic acid, 2-chloroethanol (ethylene chlorohydrin), hydrazine, hydrocyanic acid, 2-methylaziridine (propylenimine), 2-methyl-acetonitrile (acetone cyanohydrin), methyl ester isocyanic acid (methyl isocyanate), nicotine, tetranitromethane and tetraethylstannane (tetraethyltin).
3. Solids: (aceto) phenylmercury (phenyl mercuric acetate), 4-aminopyridine, arsenic pentoxide, arsenic trioxide, calcium cyanide, 2-chloroacetophenone, aflatoxin B, decaborane(14), mercury (II) bromide (mercuric bromide), mercury (II) chloride (*corrosive* mercury chloride), pentachlorophenol, methyl parathion, phosphorus (white) and sodium azide.

E102.2.2 Toxic materials.

Examples include:

1. Gases: boron trichloride, boron trifluoride, chlorine, chlorine trifluoride, hydrogen fluoride, hydrogen sulfide, phosgene, silicon tetrafluoride.
2. Liquids: acrylonitrile, allyl alcohol, alpha-chlorotoluene, aniline, 1-chloro-2,3-epoxypropane, chloroformic acid (allyl ester), 3-chloropropene (allyl chloride), o-cresol, crotonaldehyde, dibromomethane, diisopropylamine, diethyl ester sulfuric acid, dimethyl ester sulfuric acid, 2-furaldehyde (furfural), furfural alcohol, phosphorus chloride, phosphoryl chloride (phosphorus oxychloride) and thionyl chloride.
3. Solids: acrylamide, barium chloride, barium (II) nitrate, benzidine, p-benzoquinone, beryllium chloride, cadmium chloride, cadmium oxide, chloroacetic acid, chlorophenylmercury (phenyl mercuric chloride), chromium (VI) oxide (chromic acid, solid), 2,4-dinitrotoluene, hydroquinone, mercury chloride (calomel), mercury (II) sulfate (mercuric sulfate), osmium tetroxide, oxalic acid, phenol, P-phenylenediamine, phenylhydrazine, 4-phenylmorpholine, phosphorus sulfide, potassium fluoride, potassium hydroxide, selenium (IV) disulfide and sodium fluoride.

E102.2.3 Corrosives.

Examples include:

1. Acids: Examples: chromic, formic, hydrochloric (muriatic) greater than 15 percent, hydrofluoric, nitric (greater than 6 percent, perchloric, sulfuric (4 percent or more).
2. Bases (alkalis): hydroxides-ammonium (greater than 10 percent), calcium, potassium (greater than 1 percent), sodium (greater than 1 percent); certain carbonates-potassium.
3. Other corrosives: bromine, chlorine, fluorine, iodine, ammonia.

Note: Corrosives that are oxidizers (for example, nitric acid, chlorine, fluorine), compressed gases (for example, ammonia, chlorine, fluorine), or water-reactive (for example, concentrated sulfuric acid, sodium hydroxide) are physical hazards in addition to being health hazards.

SECTION E102
HAZARD CATEGORIES

E102.1 Physical hazards.

Materials classified in this section pose a physical hazard.

E102.1.1 Explosives and blasting agents.

The current UN/DOT classification system recognized by international authorities, the Department of Defense and others classifies all explosives as Class 1 materials. They are then divided into six separate divisions to indicate their relative hazard. There is not a direct correlation between the designations used by the old DOT system and those used by the current system nor is there correlation with the system (high and low) established by the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF). Table 5604.3 provides some guidance with regard to the current categories and their relationship to the old categories. Some items appear in more than one division, depending on factors such as the degree of confinement or separation, type of packaging, storage configuration or state of assembly.

In order to determine the level of hazard presented by explosive materials, testing to establish quantitatively their explosive nature is required. There are numerous test methods that have been used to establish the character of an explosive material. Standardized tests, required for finished goods containing explosives or explosive materials in a packaged form suitable for shipment or storage, have been established by UN/DOT and BATF. However, these tests do not consider key elements that should be examined in a manufacturing situation. In manufacturing operations, the condition and/or the state of a material may vary within the process. Potentially, material classification and the requirements used to determine that classification during manufacturing will differ from the classification of the same material found in finished goods. A classification methodology must be used that recognizes the hazards commensurate with the application to the variable physical conditions as well as potential variations of physical character and type of explosive under consideration.

Test methods or guidelines for hazard classification of energetic materials used for in-process operations shall be approved by the fire code official. Test methods used shall be DOD, BATF, UN/DOT or other approved criteria. The results of such testing shall become a portion of the files of the jurisdiction and be included as an independent section of any Hazardous Materials Management Plan (HMMP) required by Section 5605.2.1. Also see Section 104.8.2.

Examples of materials in various Divisions are as follows:

1. Division 1.1 (High Explosives). Consists of explosives that have a mass explosion hazard. A mass explosion is one that affects almost the entire pile of material instantaneously. Includes substances that, where tested in accordance with approved methods, can be caused to detonate by means of a blasting cap where unconfined or will transition from deflagration to a detonation where confined or unconfined. Examples: dynamite, TNT, nitroglycerine, C-3, HMX, RDX, encased explosives, military ammunition.
2. Division 1.2 (Low Explosives). Consists of explosives that have a projection hazard, but not a mass explosion hazard. Examples: nondetonating encased explosives, military ammunition and the like.
3. Division 1.3 (Low Explosives). Consists of explosives that have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard. The major hazard is radiant heat or violent burning, or both. Can be deflagrated where confined. Examples: smokeless powder, propellant explosives, display fireworks.
4. Division 1.4. Consists of explosives that pose a minor explosion hazard. The explosive effects are largely confined to the package and no projection of fragments of appreciable size or range is expected. An internal fire must not cause virtually instantaneous explosion of almost the entire contents of the package. Examples: squibs (nondetonating igniters), explosive actuators, explosive trains (low-level detonating cord).
5. Division 1.5 (Blasting Agents). Consists of very insensitive explosives. This division comprises substances that have a mass explosion hazard, but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport. Materials are not cap sensitive; however, they are mass detonating where provided with sufficient input. Examples: oxidizer and liquid fuel slurry mixtures and gels, ammonium nitrate combined with fuel oil.
6. Division 1.6. Consists of extremely insensitive articles that do not have a mass explosive hazard. This division comprises articles that contain only extremely insensitive detonating substances and that demonstrate a negligible probability of accidental initiation or propagation. Although this category of materials has been defined, the primary application is currently limited to military uses. Examples: Low vulnerability military weapons.

Explosives in each division are assigned a compatibility group letter by the Associate Administrator for Hazardous Materials Safety (DOT) based on criteria specified by DOTn 49 CFR. Compatibility group letters are used to specify the

controls for the transportation and storage related to various materials to prevent an increase in hazard that might result if certain types of explosives were stored or transported together. Altogether, there are 35 possible classification codes for explosives, for example, 1.1A, 1.3C, 1.4S.

E102.1.2 Compressed gases.

Examples include:

1. Flammable: acetylene, carbon monoxide, ethane, ethylene, hydrogen, methane. Ammonia will ignite and burn although its flammable range is too narrow for it to fit the definition of "Flammable gas."

   For binary mixtures where the hazardous component is diluted with a nonflammable gas, the mixture shall be categorized in accordance with CGA P-23.
2. Oxidizing: oxygen, ozone, oxides of nitrogen, chlorine and fluorine. Chlorine and fluorine do not contain oxygen but reaction with flammables is similar to that of oxygen.
3. Corrosive: ammonia, hydrogen chloride, fluorine.
4. Highly toxic: arsine, cyanogen, fluorine, germane, hydrogen cyanide, nitric oxide, phosphine, hydrogen selenide, stibine.
5. Toxic: chlorine, hydrogen fluoride, hydrogen sulfide, phosgene, silicon tetrafluoride.
6. Inert (chemically unreactive): argon, helium, krypton, neon, nitrogen, xenon.
7. Pyrophoric: diborane, dichloroborane, phosphine, silane.
8. Unstable (reactive): butadiene (unstabilized), ethylene oxide, vinyl chloride.

E102.1.3 Flammable and combustible liquids.

Examples include:

1. Flammable liquids.

   Class IA liquids shall include those having flash points below 73°F (23°C) and having a boiling point at or below 100°F (38°C).

   Class IB liquids shall include those having flash points below 73°F (23°C) and having a boiling point at or above 100°F (38°C).

   Class IC liquids shall include those having flash points at or above 73°F (23°C) and below 100°F (38°C).
2. Combustible liquids.

   Class II liquids shall include those having flash points at or above 100°F (38°C) and below 140°F (60°C).

   Class IIIA liquids shall include those having flash points at or above 140°F (60°C) and below 200°F (93°C).

   Class IIIB liquids shall include those liquids having flash points at or above 200°F (93°C).

E102.1.4 Flammable solids.

Examples include:

1. Organic solids: camphor, cellulose nitrate, naphthalene.
2. Inorganic solids: decaborane, lithium amide, phosphorous heptasulfide, phosphorous sesquisulfide, potassium sulfide, anhydrous sodium sulfide, sulfur.
3. Combustible metals (except dusts and powders): cesium, magnesium, zirconium.

E102.1.5 Combustible dusts and powders.

Finely divided solids that could be dispersed in air as a dust cloud: wood sawdust, plastics, coal, flour, powdered metals (few exceptions).

E102.1.6 Combustible fibers.

See the definition of combustible fibers in Section 202.

E102.1.7 Oxidizers.

Examples include:

1. Gases: oxygen, ozone, oxides of nitrogen, fluorine and chlorine (reaction with flammables is similar to that of oxygen).
2. Liquids: bromine, hydrogen peroxide, nitric acid, perchloric acid, sulfuric acid.
3. Solids: chlorates, chromates, chromic acid, iodine, nitrates, nitrites, perchlorates, peroxides.

E102.1.7.1 Examples of liquid and solid oxidizers according to hazard.

Examples include: Class 4: ammonium perchlorate (particle size greater than 15 microns), ammonium permanganate, guanidine nitrate, hydrogen peroxide solutions more than 91 percent by weight, perchloric acid solutions more than 72.5 percent by weight, potassium superoxide, tetranitromethane.

Class 3: ammonium dichromate, calcium hypochlorite (over 50 percent by weight), chloric acid (10 percent maximum

concentration), hydrogen peroxide solutions (greater than 52 percent up to 91 percent), mono-(trichloro)-tetra-(monopotassium dichloro)-penta-s-triazinetrione, nitric acid, (fuming—more than 86 percent concentration), perchloric acid solutions (60 percent to 72 percent by weight), potassium bromate, potassium chlorate, potassium dichloro-s-triazinetrione (potassium dichloro-isocyanurate), potassium perchlorate (99 percent), potassium permanganate (greater than 97.5 percent), sodium bromate, sodium chlorate and sodium chlorite (over 40 percent by weight).

Class 2: barium bromate, barium chlorate, barium hypochlorite, barium perchlorate, barium permanganate, 1-bromo-3-chloro-5, 5-dimethylhydantoin, calcium chlorate, calcium chlorite, calcium hypochlorite (50 percent or less by weight), calcium perchlorate, calcium permanganate, calcium peroxide (75 percent), chromium trioxide (chromic acid), copper chlorate, halane (1, 3-dichloro-5, 5-dimethyl-hydantoin), hydrogen peroxide (greater than 27.5 percent up to 52 percent), lead perchlorate, lithium chlorate, lithium hypochlorite (more than 39 percent available chlorine), lithium perchlorate, magnesium bromate, magnesium chlorate, magnesium perchlorate, mercurous chlorate, nitric acid (more than 40 percent but less than 86 percent), perchloric acid solutions (more than 50 percent but less than 60 percent), potassium peroxide, potassium superoxide, silver peroxide, sodium chlorite (40 percent or less by weight), sodium dichloro-s-triazinetrione anhydrous (sodium dichloroisocyanurate anhydrous), sodium perchlorate, sodium perchlorate monohydrate, sodium permanganate, sodium peroxide, sodium persulfate (99 percent), strontium chlorate, strontium perchlorate, thallium chlorate, urea hydrogen peroxide, zinc bromate, zinc chlorate and zinc permanganate.

Class 1: all inorganic nitrates (unless otherwise classified), all inorganic nitrites (unless otherwise classified), ammonium persulfate, barium peroxide, hydrogen peroxide solutions (greater than 8 percent up to 27.5 percent), lead dioxide, lithium hypochlorite (39 percent or less available chlorine), lithium peroxide, magnesium peroxide, manganese dioxide, nitric acid (40 percent concentration or less), perchloric acid solutions (less than 50 percent by weight), potassium dichromate, potassium monopersulfate (45 percent $KHSO_5$ or 90 percent triple salt), potassium percarbonate, potassium persulfate, sodium carbonate peroxide, sodium dichloro-s-triazinetrione dihydrate, sodium dichromate, sodium perborate (anhydrous), sodium perborate monohydrate, sodium perborate tetra-hydrate, sodium percarbonate, strontium peroxide, trichloro-s-triazinetrione (trichloroisocyanuric acid) and zinc peroxide.

E102.1.8 Organic peroxides.

Organic peroxides contain the double oxygen or peroxy (-o-o) group. Some are flammable compounds and subject to explosive decomposition. They are available as:

1. Liquids.
2. Pastes.
3. Solids (usually finely divided powders).

E102.1.8.1 Classification of organic peroxides according to hazard.

Examples include: Unclassified: Unclassified organic peroxides are capable of detonation and are regulated in accordance with Chapter 56.

Class I: acetyl cyclohexane sulfonyl 60-65 percent concentration by weight, fulfonyl peroxide, benzoyl peroxide over 98 percent concentration, t-butyl hydroperoxide 90 percent, t-butyl peroxyacetate 75 percent, t-butyl peroxyisopropylcarbonate 92 percent, diisopropyl peroxydicarbonate 100 percent, di-n-propyl peroxydicarbonate 98 percent, and di-n-propyl peroxydicarbonate 85 percent.

Class II: acetyl peroxide 25 percent, t-butyl hydroperoxide 70 percent (with DTBP and t-BuOH diluents), t-butyl peroxybenzoate 98 percent, t-butyl peroxy-2-ethylhexanoate 97 percent, t-butyl peroxyisobutyrate 75 percent, t-butyl peroxyisopropyl-carbonate 75 percent, t-butyl peroxypivalate 75 percent, dybenzoyl peroxydicarbonate 85 percent, di-sec-butyl peroxydicarbonate 98 percent, di-secbutyl peroxydicarbonate 75 percent, 1,1-di-(t-butylperoxy)-3,5,5-trimethyecyclohexane 95 percent, di-(2-ethythexyl) peroxydicarbonate 97 percent, 2,5-dymethyl-2-5 di (benzoylperoxy) hexane 92 percent, and peroxyacetic acid 43 percent.

Class III: acetyl cyclohexane sulfonal peroxide 29 percent, benzoyl peroxide 78 percent, benzoyl peroxide paste 55 percent, benzoyl peroxide paste 50 percent peroxide/50 percent butylbenzylphthalate diluent, cumene hydroperoxide 86 percent, di-(4-butylcyclohexyl) peroxydicarbonate 98 percent, t-butyl peroxy-2-ethylhexanoate 97 percent, t-butyl peroxyneodecanoate 75 percent, decanoyl peroxide 98.5 percent, di-t-butyl peroxide 99 percent, 1,1-di-(t-butylperoxy)3,5,5-trimethylcyclohexane 75 percent, 2,4-dichlorobenzoyl peroxide 50 percent, di-isopropyl peroxydicarbonate 30 percent, 2,-5-dimethyl-2,5-di-(2-ethylhexanolyperoxy)-hexane 90 percent, 2,5-dimethyl-2,5-di-(t-butylperoxy) hexane 90 percent and methyl ethyl ketone peroxide 9 percent active oxygen diluted in dimethyl phthalate.

Class IV: benzoyl peroxide 70 percent, benzoyl peroxide paste 50 percent peroxide/15 percent water/35 percent butylphthalate diluent, benzoyl peroxide slurry 40 percent, benzoyl peroxide powder 35 percent, t-butyl hydroperoxide 70 percent, (with water diluent), t-butyl peroxy-2-ethylhexanoate 50 percent, decumyl peroxide 98 percent, di-(2-ethylhexal) peroxydicarbonate 40 percent, laurel peroxide 98 percent, p-methane hydroperoxide 52.5 percent, methyl ethyl ketone peroxide 5.5 percent active oxygen and methyl ethyl ketone peroxide 9

percent active oxygen diluted in water and glycols.

Class V: benzoyl peroxide 35 percent, 1,1-di-t-butyl peroxy 3,5,5-trimethylcyclohexane 40 percent, 2,5-di-(t-butyl peroxy) hexane 47 percent and 2,4-pentanedione peroxide 4 percent active oxygen.

E102.1.9 Pyrophoric materials.

Examples include:

1. Gases: diborane, phosphine, silane.
2. Liquids: diethylaluminum chloride, di-ethylberyllium, diethylphosphine, diethylzinc, dimethylarsine, triethylaluminum etherate, tri-ethylbismuthine, triethylboron, trimethylaluminum, trimethylgallium.
3. Solids: cesium, hafnium, lithium, white or yellow phosphorous, plutonium, potassium, rubidium, sodium, thorium.

E102.1.10 Unstable (reactive) materials.

Examples include:

Class 4: acetyl peroxide, dibutyl peroxide, dinitrobenzene, ethyl nitrate, peroxyacetic acid and picric acid (dry) trinitrobenzene.

Class 3: hydrogen peroxide (greater than 52 percent), hydroxylamine, nitromethane, paranitroaniline, perchloric acid and tetrafluoroethylene monomer.

Class 2: acrolein, acrylic acid, hydrazine, methacrylic acid, sodium perchlorate, styrene and vinyl acetate.

Class 1: acetic acid, hydrogen peroxide 35 percent to 52 percent, paraldehyde and tetrahydrofuran.

E102.1.11 Water-reactive materials.

Examples include:

Class 3: aluminum alkyls such as triethylaluminum, isobutylaluminum and trimethylaluminum; bromine pentafluoride, bromine trifluoride, chlorodiethylaluminium and diethylzinc.

Class 2: calcium carbide, calcium metal, cyanogen bromide, lithium hydride, methyldichlorosilane, potassium metal, potassium peroxide, sodium metal, sodium peroxide, sulfuric acid and trichlorosilane.

Class 1: acetic anhydride, sodium hydroxide, sulfur monochloride and titanium tetrachloride.

E102.1.12 Cryogenic fluids.

The cryogenics listed will exist as compressed gases where they are stored at ambient temperatures.

1. Flammable: carbon monoxide, deuterium (heavy hydrogen), ethylene, hydrogen, methane.
2. Oxidizing: fluorine, nitric oxide, oxygen.
3. Corrosive: fluorine, nitric oxide.
4. Inert (chemically unreactive): argon, helium, krypton, neon, nitrogen, xenon.
5. Highly toxic: fluorine, nitric oxide.

E102.2 Health hazards.

Materials classified in this section pose a health hazard.

E102.2.1 Highly toxic materials.

Examples include:

1. Gases: arsine, cyanogen, diborane, fluorine, germane, hydrogen cyanide, nitric oxide, nitrogen dioxide, ozone, phosphine, hydrogen selenide, stibine.
2. Liquids: acrolein, acrylic acid, 2-chloroethanol (ethylene chlorohydrin), hydrazine, hydrocyanic acid, 2-methylaziridine (propylenimine), 2-methyl-acetonitrile (acetone cyanohydrin), methyl ester isocyanic acid (methyl isocyanate), nicotine, tetranitromethane and tetraethylstannane (tetraethyltin).
3. Solids: (aceto) phenylmercury (phenyl mercuric acetate), 4-aminopyridine, arsenic pentoxide, arsenic trioxide, calcium cyanide, 2-chloroacetophenone, aflatoxin B, decaborane(14), mercury (II) bromide (mercuric bromide), mercury (II) chloride (*corrosive* mercury chloride), pentachlorophenol, methyl parathion, phosphorus (white) and sodium azide.

E102.2.2 Toxic materials.

Examples include:

1. Gases: boron trichloride, boron trifluoride, chlorine, chlorine trifluoride, hydrogen fluoride, hydrogen sulfide, phosgene, silicon tetrafluoride.
2. Liquids: acrylonitrile, allyl alcohol, alpha-chlorotoluene, aniline, 1-chloro-2,3-epoxypropane, chloroformic acid (allyl ester), 3-chloropropene (allyl chloride), o-cresol, crotonaldehyde, dibromomethane, diisopropylamine, diethyl ester sulfuric acid, dimethyl ester sulfuric acid, 2-furaldehyde (furfural), furfural alcohol, phosphorus chloride,

phosphoryl chloride (phosphorus oxychloride) and thionyl chloride.

3. Solids: acrylamide, barium chloride, barium (II) nitrate, benzidine, p-benzoquinone, beryllium chloride, cadmium chloride, cadmium oxide, chloroacetic acid, chlorophenylmercury (phenyl mercuric chloride), chromium (VI) oxide (chromic acid, solid), 2,4-dinitrotoluene, hydroquinone, mercury chloride (calomel), mercury (II) sulfate (mercuric sulfate), osmium tetroxide, oxalic acid, phenol, P-phenylenediamine, phenylhydrazine, 4-phenylmorpholine, phosphorus sulfide, potassium fluoride, potassium hydroxide, selenium (IV) disulfide and sodium fluoride.

E102.2.3 Corrosives.

Examples include:

1. Acids: Examples: chromic, formic, hydrochloric (muriatic) greater than 15 percent, hydrofluoric, nitric (greater than 6 percent, perchloric, sulfuric (4 percent or more).
2. Bases (alkalis): hydroxides-ammonium (greater than 10 percent), calcium, potassium (greater than 1 percent), sodium (greater than 1 percent); certain carbonates-potassium.
3. Other corrosives: bromine, chlorine, fluorine, iodine, ammonia.

Note: Corrosives that are oxidizers (for example, nitric acid, chlorine, fluorine), compressed gases (for example, ammonia, chlorine, fluorine), or water-reactive (for example, concentrated sulfuric acid, sodium hydroxide) are physical hazards in addition to being health hazards.